Title: Estimated Extent of Coastal Flooding due to Sea Level Change and Storm Surge for 118 U.S. National Parks

Abstract: This data release consists of the estimated extent of coastal flooding due to sea level change and storm surge for the U.S. national coastal parks of the continental United States, Alaska, Hawaii, Puerto Rico, U.S. Virgin Islands, American Samoa, and Guam. The data and inundation results enable coastal flooding analysis and display at high resolution for 118 parks.

The estimated inundation extent was achieved by utilizing a modified bathtub approach as developed by the Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Coastal Services Center (CSC) (Allen et al., 2010). The NOAA methodology "attempts to account for local and regional tidal variability and hydrological connectivity". Sea level change polygon extents consist of 4 model-run scenarios using sea level change maps produced by Dr. R. Steven Nerem's group at the Colorado Center for Astrodynamics Research at the University of Colorado in Boulder (Church et al., 2013). The maps are based on Representative Concentration Pathways (RCP), which are four greenhouse gas concentration trajectories. Two RCPs were chosen for this study, a moderate RCP, 4.5 and the most extreme RCP, 8.5. Each RCP was projected to the years 2050 and 2100. Storm surge estimated extent polygons were generated using the same modified bathtub approach for RCP 8.5, year 2050 and year 2100 plus storm surge. Storm surge values were derived from 2 sources; National Weather Service (NWS) SLOSH (Sea, Lake, and Overland Surges from Hurricanes) MOM (Maximum of the Mean Envelope of Overwash Water (MEOW)) (Jelesnianski et al.,1992) and in areas where SLOSH output is not available then historic patterns of extreme high water events at tide gauges was used (Tebaldi et al., 2012).

Other data available in this series includes low-lying areas, defined by NOAA as "hydrologically "unconnected" areas that may flood"; the DEM used to model the inundation; and USGS DEMs for selected park units.

The estimated extents and model DEM are available in ArcGIS personal geodatabase format. The USGS DEMs are available in geoTIFF format. The extents and model DEM have a UTM projection and NAD83 (2011) datum. The USGS DEMs have a geographic projection, NAD83 horizontal datum, and NAVD88 vertical datum unless noted otherwise. With questions, please contact Dr. Rebecca Beavers, Coastal Geology and Coastal Adaptation to Climate Change Coordinator, National Park Service, rebecca_beavers@nps.gov, 303-987-6945.

Purpose (As written by NOAA): "The purpose of this data viewer is to provide coastal managers and scientists with a preliminary look at sea level rise and coastal flooding impacts. The viewer is a screening-level tool that uses nationally consistent data sets and analyses. Data and maps provided can be used at several scales to help gauge trends and prioritize actions for different scenarios."

Other_Citation_Details: Please give data set credit as below and cite as: Caffrey, M., L. Lestak, W. Manley, and A. Forget, 2015, Estimated Extent of Coastal Flooding due to Sea Level

Change and Storm Surge for 118 U.S. National Parks: NPS NRSS, University of Colorado at Boulder, digital media.

Use_Constraints: Dataset credit required. All improvements made to original data are not the responsibility of the National Park Service (NPS) or the Institute of Arctic and Alpine Research (INSTAAR). The user of National Park Service data agrees not to resell or redistribute shared data. Use at your own risk. Users assume responsibility to determine the usability of the dataset, as well as dataset resolution and accuracy, for their purposes. It is not recommended that the data be used at a scale larger than source scale.

NOAA Disclaimer: "The data and maps in this tool illustrate the scale of potential flooding, not the exact location, and do not account for erosion, subsidence, or future construction. Water levels are shown as they would appear during the highest high tides (excludes wind driven tides). The data, maps, and information provided should be used only as a screening-level tool for management decisions. As with all remotely sensed data, all features should be verified with a site visit. The data and maps in this tool are provided "as is", without warranty to their performance, merchantable state, or fitness for any particular purpose. The entire risk associated with the results and performance of these data is assumed by the user. This tool should be used strictly as a planning reference tool and not for navigation, permitting, or other legal purposes.

Low-lying areas, displayed in green, are hydrologically "unconnected" areas that may flood. They are determined solely by how well the elevation data captures the area's hydraulics. A more detailed analysis of these areas is required to determine the susceptibility to flooding."

Data_Set_Credit:
Sea Level Rise and Surge Layers: The following acknowledgment should accompany any publication or citation of these data: Logistical support and/or data were provided by the National Park Service. The user of NPS data agrees to provide proper acknowledgment with each usage of the data. Citation of the name(s) of the investigator(s) responsible for the data set. In addition to the generic statement above, constitute proper acknowledgment.
Contact_Person: Dr. Rebecca Beavers
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NOAA DEMS and MHHW Grids: Acknowledgment of the Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Coastal Services Center (CSC) would be appreciated in products developed from these data, and such acknowledgment as is standard for citation and legal practices for data source is expected.

Python code and NOAA Methodology assistance: Billy Brooks, GISP
Geospatial Analyst, The Baldwin Group, NOAA Office for Coastal Management, 2234 S Hobson Ave, Charleston, SC 29405, (843) 740-1319 and Doug Marcy, NOAA Office for Coastal Management, 2234 S. Hobson Avenue, Charleston, SC 29405, 843-740-1334, doug.marcy@noaa.gov

IPCC RPC Sea Level Change layers: Produced by Dr. R. Steven Nerem's group at the Colorado Center for Astrodynamics Research at the University of Colorado in Boulder. Church, J. A., P. U. Clark, A. Cazenave, J. M. Gregory, S. Jevrejeva, A. Levermann, M. A. Merrifield, G. A. Milne, R. S. Nerem, P. D. Nunn, A. J. Payne, W. T. Pfeffer, D. Stammer and A. S. Unnikrishnan, Sea Level Change, In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013.

USGS NED DEMs: U.S. Geological Survey, USGS National Elevation Dataset (NED), USGS National Geospatial Program Office, 12201 Sunrise Valley Drive, Reston, VA, 20192, 1-888-ASK-USGS (1-888-275-8747).

Glynn County DEM: Glynn County, Georgia, GIS Department, 2007 LIDAR Survey, Fort Frederica Area Digital Elevation Model(DEM)

Grid_Coordinate_System_Name: Universal Transverse Mercator (when possible)
Horizontal_Datum_Name: North American Datum of 1983 (2011) (when possible)
Planar_Distance_Units: meters
Altitude_Distance_Units: meters

Below is from the NOAA Methodology document (NOAA_Inundation_Methods.pdf):

Purpose:

- Use best publically available and accessible elevation data
- Map literature-supported levels of sea level rise
- Map sea level rise on top of mean higher high water (MHHW)
- Incorporate local and regional tidal variation of MHHW for each area
- Evaluate inundation for hydrological connectivity
- Preserve hydrologically unconnected areas greater than one acre in size, but display separately from hydrologically connected inundation

Disclaimer:

- These data are for planning, educational, and awareness purposes only and should not be used for site-specific analysis, navigation, or permitting.
- The mapping does not incorporate future changes in coastal geomorphology and assumes present conditions will persist, which will not be the case.
- The digital elevation model used to map sea level rise does not incorporate a detailed pipe network analysis, or engineering grade hydrologic analysis (for example, culverts and ditches may not be incorporated resulting in incorrectly mapped areas). Therefore, hydrologically unconnected areas of inundation are still displayed, though symbolized differently than hydrologically connected inundation.

Process Description:

Generally, this process can be described as a modified bathtub approach that attempts to account for local and regional tidal variability and hydrological connectivity. Generally, the same process as that used by NOAA was implemented. For more detailed process information read the included document which can be found in the "Metadata" folder, NOAA_Inundation_Methods.pdf.

Changes to the NOAA methods are as follows: 1) Sea level rise was derived from IPCC spatial layers (Church, et al., 2013) instead of assigning static 1-6 foot amounts; 2) NOAA did not model sea level rise in Alaska, 60 meter (2 arc second) USGS DEMs were used for this project and tide gauge information was used to calculate the MHHW levels; 3) NOAA did not model surge, for this project surge inundation polygons were calculated by adding to the IPCC sea level rise spatial layer, where available, SLOSH MOM model output (Jelesnianski, et al. 1992) or Tebaldi gauge calculations (Tebaldi, et al. 2012).

Sea level rise (SLR) layers generated by Nerem's group were modified to run the NOAA model. The SLR layers were modified to extend inland. Data was shifted to the west on the east coast, to the north on the south coasts and to the east on the west coast. On the west coast surge values were input as a constant value across the NPS model domain from the Tebaldi gauge calculations. In areas that had SLOSH MOM output, the polygon layer was converted to an equally-spaced point layer and then the point data was kriged to cover the extent of the NPS model domain. Alaska tidal information obtained from local tide gauge data was input as a constant value across the NPS model domain.

Horizontal, vertical, and attribute accuracy values were not derived for each inundation output polygon. Each NPS model domain contains different accuracies depending on which input data was used for each model run. Accuracy estimates can be derived by viewing the individual metadata for each layer that was input into the NOAA model.

For information on which DEMs and which tidal layers or gauges were used for each model domain and corresponding park unit code see this document, "0Readme_Domains_vs2.xlsx" which is included with this data distribution. FGDC metadata for each NOAA DEM can be found in the "Metadata/ NOAA_DEM_metafiles" folder which is included with this data distribution. Information about the Glynn County DEM is in the "Glynn_County_LiDAR DEM Report 11_14_08.pdf" which is in the "Metadata" directory included with this data distribution. USGS DEM accuracy metadata is also in the "Metadata" directory in the "Gesch_etal_2014_ofr2014-1008.pdf" document.

For process and accuracy information pertaining to the NOAA MHHW tidal surface layers and NOAA MHHW gauge information see the following documents which are included in the "Metadata" folder in this data distribution.
00_InterpolatedTidalSurfaces_Documentation.doc
00_American Samoa MHHW Tidal Surface.doc
00_NOAA SLR Viewer - CNMI Tidal Surfaces.doc

00_NOAA SLR Viewer - Guam Tidal Surfaces.doc

For tidal gauge information used for the Alaska model runs see the “Tidal_Datums_Used_for_AK.pdf” document documents, which is included in the “Metadata” folder in this data distribution.

For surge layers or gauge information used for each Park Unit Code see the “0Readme_Surge_vs2.xlsx” document which is included with this data distribution and refer to the “Jelesnianski_etal_1992_SLOSH_TR48.pdf” or “Tebaldi et al. 2012.pdf” document in the “Metadata” folder.

References (All references have been included in the data distribution in the “Metadata” folder):

Allen, A., S. Gill, D. Marcy, M. Honeycutt and J. Mills, 2010. Technical Considerations for Use of Geospatial Data in Sea Level Change Mapping and Assessment. NOAA Technical Report NOS 2010-01, National Oceanic and Atmospheric Administration, National Ocean Service, Washington, DC, 2010.

Church, J. A., P. U. Clark, A. Cazenave, J. M. Gregory, S. Jevrejeva, A. Levermann, M. A. Merrifield, G. A. Milne, R. S. Nerem, P. D. Nunn, A. J. Payne, W. T. Pfeffer, D. Stammer and A. S. Unnikrishnan, Sea Level Change, In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2013.

Gesch, D.B., Oimoen, M.J., and Evans, G.A., 2014, Accuracy assessment of the U.S. Geological Survey National Elevation Dataset, and comparison with other large-area elevation datasets—SRTM and ASTER: U.S. Geological Survey Open-File Report 2014–1008, 10 p., http://dx.doi.org/10.3133/ofr20141008.

Jelesnianski, C.P., J. Chen, W.A. Shaffer, 1992. SLOSH: Sea, Lake, and Overland Surges from Hurricanes: NOAA Technical Report NWS 48, National Oceanic and Atmospheric Administration, National Weather Service, Washington, DC, 1992.

Tebaldi, C., Strauss, B.H. and C.E. Zervas, 2012. Modelling sea level rise impacts on storm surges along US coasts. Environmental Research Letters, 7, 014032 doi:10.1088/1748-9326/7/1/014032.